Super Polishing of Aluminum 6061-T6 Mirrors, Phase I

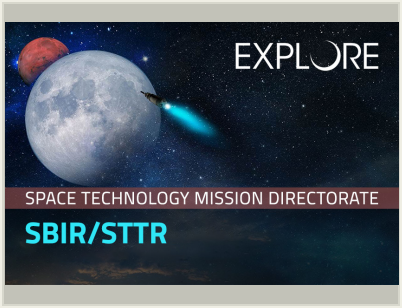
Completed Technology Project (2009 - 2009)

Project Introduction

An innovative 2D super-polishing process for Aluminum 6061-T6 planar mirrors which removes diamond point turning (DPT) grooves and attains rms surface finishes below 10 Angstroms has been developed. Present techniques for post-polishing of DPT grooves fail to completely remove the periodic structure resulting in a loss of specular energy into undesired diffracted orders. The long-term objectives of this project are to transfer the 2D process onto a 3D polishing platform, and to develop robust, automated production processes for both 2D and 3D Aluminum optics. Once achieved, this will be the most significant advance in the polishing field in many decades. Super-polished surface finishes below 10 Angstroms will allow scientific instruments utilizing mirrors to achieve results at or near their theoretical limits. Robust, automated production processes for Aluminum optics will result in significant improvements in the technical performance and cost-effectiveness of optics in many scientific and commercial markets. The general methodology for achieving these goals is to collaborate with Zeeko Technologies and use well-chosen designed experiments that will efficiently screen the tool parameter response space and identify the best operating window to achieve super-polished surface finishes on the Zeeko IRP200 platform. The technology for producing super-polished Aluminum optics will assist NASA in surpassing optical specifications required in upcoming missions such as Terrestrial Planet Finder (TPF), Single Aperture Far Infrared Observatory (SAFIR), International X-ray Observatory (IXO), and Space Interferometry Mission (SIM Lite). Aluminum 6061-T6 has been used extensively in past optical designs and it will continue to play a critical role in these and future NASA missions.

Anticipated Benefits

The super-polishing technology is a fundamental improvement to a basic manufacturing process which will enable mirror components to operate near theoretical limits. Economically priced, super-polished Aluminum 6061-T6 mirrors will have a broad market pull because 2D and 3D mirrors are a critical optical components in a variety of markets. Examples of targeted applications of super-polished Aluminum 6061-T6 relative to other government agencies include Concentrating Solar Power mirrors for research programs at DoE run facilities such as National Renewable Energy Laboratory and Sandia National Laboratories. Fine steering mirrors and component mirrors for imaging and remote sensing for DoD and Defense Missile Agency. Some targeted commercial applications of super-polished Aluminum 6061-T6 include component mirrors for imaging/scanning instruments used in semiconductor manufacturing lines. High energy laser reflectors also require superior metal surfaces; otherwise surface defects absorb too much incident energy causing mirrors to catastrophically fail. And finally, super-polishing of Aluminum mirrors for concentrating solar power (CSP) systems is another commercial application that would benefit from a fast, automated, and economical manufacturing process. The super-polishing process would improve the



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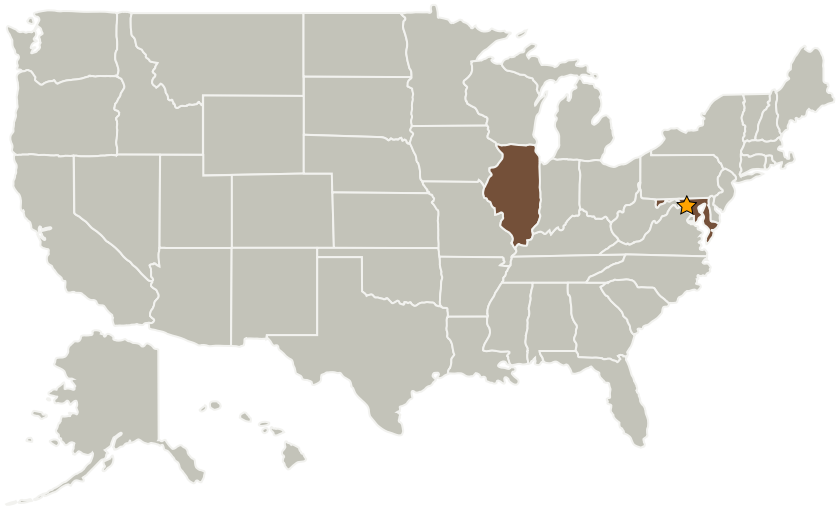
surface roughness and waviness inherent in current solar mirrors, enhancing their optical performance and efficiency of converting solar energy into electricity. Some of the potential applications of super-polished Aluminum 6061-T6 relative to the needs of NASA include the post-polishing of diamond point turned mirrors to remove the surface grooves, greatly enhancing the optical performance of the mirror in a cost-effective manner. In addition, mirrors fabricated with super-polished Aluminum 6061-T6 dovetail with NASA's needs for upcoming missions such as Terrestrial Planet Finder (TPF), Single Aperture Far Infrared Observatory (SAFIR), International X-ray Observatory (IXO), and Space Interferometry Mission (SIM Lite). Aluminum 6061-T6 has been used extensively in past optical designs and it will continue to play an important role in future missions. For example, the TPF mission, designed to detect very faint and small planets orbiting other stars, could benefit greatly from the super-polished Aluminum 6061-T6 mirror surfaces especially in the manufacturing of the fold mirrors. It is critical that all of the mirrors used to resolve the star signal from the planet's faint, reflected light have minimal scatter signatures with low mid-spatial frequencies to address the requirement for high resolution and low beam dispersion in planet detection. The Space Interferometry Mission (SIM Lite) which consists of two Michelson configured interferometers and a telescope, may also benefit from the Aluminum super-polished mirrors. Specifically, there is potential to super-polish the fine steering mirror (FSM) in the Guide 2 telescope.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Manager:

Howard J Wood

Principal Investigator:

Susan Wilson

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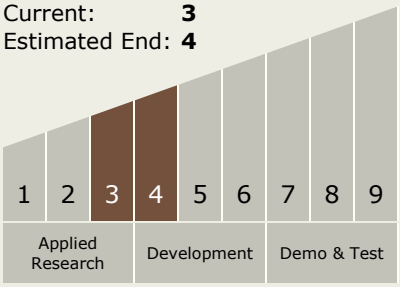
Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
Microengineered Metals, Inc.	Supporting Organization	Industry	Yorkville, Illinois

Primary U.S. Work Locations	
Illinois	Maryland

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.2 Observatories
    - TX08.2.1 Mirror Systems